 1/Pat Rec'd PCT/PTO 29 MAR 2005

10/529689

Optical record carrier for use with UV radiation beam

The present invention relates to an optical record carrier for recording and/or reading information using a radiation beam in the UV wavelength range, in particular having a wavelength in the range from 230 to 270 nm, comprising a substrate layer and an information stack comprising:

- an information layer comprising a material for forming marks and spaces representing an information by irradiation of the UV radiation beam,
- a cover layer on top of the side of the said record carrier facing the incident UV radiation beam.

Optical record carriers have seen an evolutionary increase in the data capacity by increasing the numerical aperture of the objective lens and a reduction of the radiation (e.g. laser) wavelength. The total data capacity was increased from 650 Mbyte (CD, NA=0.45, λ =780 nm) to 4.7 Gbyte (DVD, NA=0.65, λ=670 nm) to 25 Gbyte for the Blu-ray Disc (BD, NA=0.85, λ=405 nm,). The BD data density was derived from the DVD capacity by optical scaling. To achieve a further increase in data density one possibility is to further reduce the laser wavelength into the UV wavelength range. Suitable UV lasers will become available in the near future.

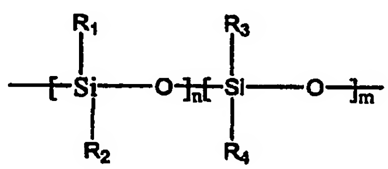
EP0731454 A1 discloses an optical recording method, optical recording apparatus and optical recording medium for use with a UV laser. A UV laser having a wavelength in the range from 190 to 370 nm and a lens having a numerical aperture of 0.4 or less shall be used to record identification information of the recording medium in a subsidiary information recording area outside the information recording area where audio, video or character data are recorded.

It is an object of the present invention to provide an optical record carrier suitable for recording and/or reading information by use of a UV radiation beam.

This object is achieved according to the present invention by an optical record carrier according to the opening paragraph which is further characterized in that said cover layer is made of a cured resin composition being a silicon based reactive material. A UV radiation beam is to be understood to have a wavelength in the range 190 - 400 nm.

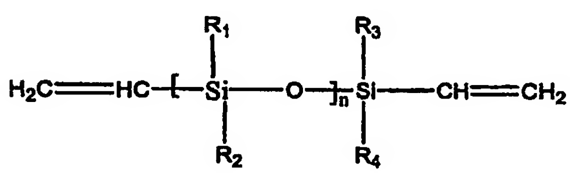
In the known optical record carriers such as CD, DVD and BD, the optical disk generally comprises an information stack sandwiched between a polycarbonate substrate layer and a plastic cover layer. The data is written and/or read–out through the transparent polycarbonate substrate layer or cover layer of the disc. However, at said UV wavelength, in particular in the range of 230 nm to 270 nm, the currently used materials for said substrate and cover layers are not transparent for the laser radiation. According to the present invention cover incidence is used for data recording and/or read-out, where the cover layer is made of materials transparent for incident UV radiation beam.

The resin composition according to the invention comprises



(1)

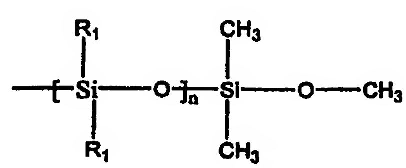
and



(2)

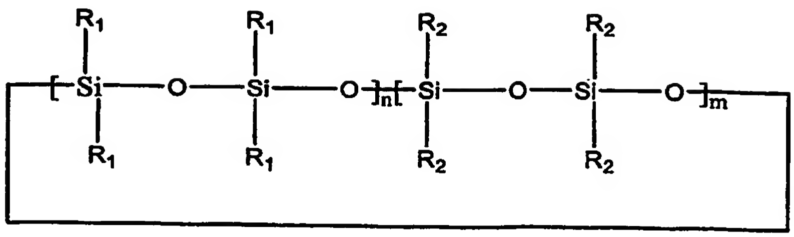
wherein R_1, R_2, R_3, R_4 = hydrogen, C_1-C_{10}-alkyl, vinyl, phenyl, hydroxide, amino, halogen atom and at least one of R_1, R_2, R_3 and R_4 is hydrogen.

In a preferred embodiment of the present invention the resin composition further comprises



(3)

wherein R_1, R_2, R_3 and R_4 have the same meaning as already disclosed before. In addition it is preferred that the resin composition further comprises



(4)

wherein R_1, R_2, R_3 and R_4 have the same meaning as already disclosed before.

It is to be noted that the resin composition also comprises a metal catalyst, e.g. a platinum based catalyst, in an amount of 5-10 ppm Pt.

It is preferred that component (1) is present in an amount of 40-70 wt.%, based on the total weight of the curable resin composition.

In addition, it is preferred that component (2) is present in an amount of 15-40 wt.%, based on the total weight of the curable resin composition.

Furthermore it is preferred that component (3) is present in an amount of 10-30 wt.%, based on the total weight of the curable resin composition.

It is preferred that component (4) is present in an amount of 1.0-5.0 wt.%, based on the total weight of the curable resin composition.

In a further embodiment the optical record carrier comprises at least one additional recording stack and at least one transparent spacer layer for separating the recording stacks from each other, said spacer layer (SP) being made of a resin composition as described above containing one or more of the components (1) – (4). Hence a spacer layer is achieved, which is substantially transparent to UV radiation.

In yet a further embodiment the optical record carrier further comprises at least one auxiliary layer comprising a material selected from the group of materials containing Al_2O_3, SiO_2, C, NaCl, ZrO, Si_3N_4, LiF, KCl, Al, Ag, Cu, Ag, Ir, Mo, Rh, Pt, Ni, Os, W. Such layer(s) may be required to improve the optical characteristics of the optical record carrier, e.g. optical reflection, optical contrast of written information. Furthermore these materials are suitable for use with UV radiation. The auxiliary layers may be, e.g., dielectric layers and/or metal layers. Most of the dielectric materials commonly used in current (DVD) and third generation (BD) phase-change optical record carriers absorb too much laser radiation at the UV recording wavelength in the range from 230 to 270nm. This has consequences for both the thermal and optical performance. For example, ZnS-SiO_2 - the material which is commonly used in optical recording stacks – has a rather high absorption coefficient in this wavelength range. In a conventional IPIM recording stack, where I denotes

the dielectric layers made of $ZnS\text{-}SiO_2$, P the phase-change information layer and M the metal heat sink layer, the significant absorption in the two dielectric layers leads to a much broader temperature distribution than would be predicted on the bases of optical scaling conditions. Since a broader temperature distribution will lead to broader marks and further to cross-write phenomena, the achieved data capacity will be of the same magnitude as that of the third generation BD record carrier.

Other dielectric materials than $ZnS\text{-}SiO_2$ are preferably required for an optical record carrier which shall be used in combination with UV radiation. Possible materials are obtained by a survey including sputter deposition and optical analysis. It has thus been found that a material from the following group of materials can be advantageously used as dielectric layer in optical record carriers according to the present invention: Al_2O_3, SiO_2, C, NaCl, ZrO, Si_3N_4 LiF, KCl. The materials can be doped to further improve the optical, thermal, and mechanical properties. As a suitable phase-change recording material which may be used in the information layer alloys comprising at least two of the materials Ge, Sb, Te, In, Se, Bi, Ag, Ga, Sn, Pb, As have been found.

In addition to the dielectric layers and the phase-change layer metal heat sink layers can be provided which are required for quick heat removal (quenching) during writing to enable mark formation. Such metal layers also serve as a reflector to enhance the read-out of data and/or absorption of the incident radiation by the recording layer. The following materials or their alloys can be used in a recording stack for optical recording in the UV wavelength range: Al, Ag, Cu, Ag, Ir, Mo, Rh, Pt, Ni, Os, W.

The invention will now be explained in more detail with reference to the drawings in which

Figs. 1 to 3 schematically show cross-sections of different embodiments of an optical record carrier according to the present invention.

In Fig. 1 an optical record carrier for recording and/or reading information using a radiation beam in the UV wavelength range, in particular having a wavelength in the range from 230 to 270 nm is shown. The optical record carrier comprises a substrate layer (S) and an information stack (R) comprising:

- an information layer (P) comprising a material for forming marks and spaces representing an information by irradiation of a UV radiation beam,

- a transparent cover layer (C) on top of the side of the said record carrier facing the incident UV radiation beam. Said cover layer (C) is made of a curable resin composition being a silicon based reactive material. Described in more detail Fig. 1 shows a first schematic layout of a record carrier comprising an M/I2/P/I1/C information stack R where M is the reflector/ heat sink layer, P is a phase-change information layer and I1 and I2 are protective/interference layers (dielectric layers) or multi-layer structures and C a cover layer for protection of the information stack, which is a so-called MIPI stack. The cover layer C can be provided on top of the I1-layer. A preferred material for said cover layer is Sylgard 184 Silicone Elastomer (product of Dow Chemicals, a mixture of components (1) – (4) mainly comprising polydimethylsiloxane) and has a thickness in a range from 5 to 300 μm. The material can be applied very well by e.g. spin-coating, a technique which is well known in the art. A layer of 100 μm of this material has a transmission at 257 nm of more than 80%. Generally the information stacks can be of either low-to-high signal polarity, where reflection of the recorded state is higher than that of the unrecorded state, or high-to-low signal polarity, where reflection of the unrecorded state is higher than that of the recorded state. Note that the information layer P is not restricted to a rewritable phase change layer. The information layer may also be a read only layer, in which case the read-only layer usually is a reflective layer provided with a relief structure containing the information. In the latter case another M layer is not necessarily required. The information layer may also be a write once layer of a suitable material, e.g. an organic dye layer or an anorganic metallic layer.

Generally the thickness of the metal heat sink /reflective layer M should be larger than 10 nm, in particular larger than 15 nm. The thickness of the phase-change information layer P should be in the range from 3 to 50 nm, in particular from 5 to 25 nm. The thickness of the second dielectric layer I2 should be in the range from 2 to 50 nm, in particular from 3 to 25 nm. The thickness of the first dielectric layer I1 should be larger than 5 nm, in particular larger than 10 nm.

As an example, a recording stack with Si_3N_4 as dielectric layers I1, I2, Al as metal heat sink layer M and In-doped Sb-Te alloy as a phase-change information layer P is preferably proposed. The stack design is S/M/I2/P/I1/C as shown in Fig. 1 where M is the first layer deposited on the disc substrate S and where the UV laser beam L, preferably at a wavelength of 266 nm, enters the stack from the I1-layer side, through the cover layer C.

Additionally on top of the cover layer C at the side facing the UV radiation-beam a transparent or semi-transparent hard-coating layer may be present (not drawn). By the hard-coating layer mechanical resistance of the record carrier can be improved. The hard-coating layer is preferably made of Si-, C-, or S-containing materials and has a thickness in the range from 5 nm to 300 μm. The P, I and M layers may be applied by known sputtering and/or evaporation techniques.

In Fig 2 a multi-layer optical record carrier, further comprising at least one additional information stack and at least one transparent spacer layer for separating the information stacks from each other, said spacer layer (SP) being made of a resin composition containing one or more of the components (1) – (4) is shown. As-depicted, the carrier has two information stacks R1, R2 separated by a spacer layer SP. The spacer layer may be provided by e.g. spin-coating. A preferred material for said spacer layer is Sylgard 184 Silicone Elastomer (product of Dow Chemicals, a mixture of components (1) – (4) mainly comprising polydimethylsiloxane) and has a thickness in a range from 1 μm to 100 µm. Such an optical record carrier has higher (in this case approximately twice) capacity than the optical record carrier comprising only one information stack. All the information stacks in such a record carrier are accessed by the incident UV radiation beam L from the same side of the record carrier.

In Fig. 3 a double-sided optical recording carrier comprising a information stack R1, R2 on each side of the substrate is shown. As depicted, the record carrier has one information stack R1, R2 per side of the substrate S. Such a record carrier has higher (in this case twice) capacity than the record carrier comprising only one information stack. In such a carrier the information stacks R1, R2 situated at the either side of the substrate S are accessed by the incident UV radiation beam L from the side of the substrate S which they are situated at. Double-sided multi-layer media can also be foreseen. Furthermore Small Form Factor Optical (SFFO) recording carriers, e.g. < 30 mm diameter, can be foreseen for use with UV radiation beams. These SFFO carriers would still be able to contain a substantial amount of data, e.g. > 2 GB, due to the high data density achievable with UV-radiation beams.

For recording and/or reading a similar apparatus as used for BD carriers, normal size as well as SFFO, can be used.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The

word "comprising", "comprise" or "comprises" does not exclude the presence of elements or steps other than those listed in a claim. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

According to the present invention an optical record carrier is proposed for use with a UV radiation beam for recording and/or reading, preferably in a wavelength range from 230 to 270 nm. Together with a numerical aperture of NA = 0.85, the effective spot radius (1/*e* of the approximate Gaussian distribution) of a system with λ=266 nm is R0=99 nm. If the effective spot area is considered it can be seen that a data capacity of 60 – 65 Gbyte is achievable for such record carriers. It can be further seen that the gained data capacity is too low for a lower numerical aperture (for instance NA=0.65) and that a numerical aperture of NA = 0.85 is required.